Historic Populations of the Double-crested Cormorant (*Phalacrocorax auritus*): Implications for Conservation and Management in the 21st Century

LINDA R. WIRES[1] AND FRANCESCA J. CUTHBERT

Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota
200 Hodson Hall, 1980 Folwell Ave., St. Paul, MN, 55108-6124, USA

[1]Corresponding author. Internet: wires001@umn.edu

Abstract.—In North America, the Double-crested Cormorant (*Phalacrocorax auritus*) is currently abundant, widely distributed across five broad geographic regions, and often perceived as overabundant. In many U.S. states and Canadian provinces, policy makers are pressured to significantly reduce cormorant numbers, primarily to minimize conflicts between cormorants and fish resources. Concurrently, large-scale conservation plans recently developed for birds in the Americas depart from the traditional narrow focus on threatened and endangered species to encompass broader and more representative goals (e.g., Partners in Flight's objective to "keep common birds common"). In recent waterbird conservation initiatives, historic distribution and abundance provide the basis for conservation focus; these initiatives advocate conservation of birds in natural numbers and natural habitats. To provide a context in which current populations of Double-crested Cormorants can be understood, we reviewed historic and current breeding and wintering records to determine historic distribution (pre-1900), current distribution (1970-1999), and extent of range expansion across North America. Early records suggest Double-crested Cormorants were present in large numbers throughout much of their current range; colonies and flocks much larger than any known in the 1990s are well documented. However, numbers sharply declined through the late 1800s as cormorants were greatly reduced and/or extirpated in many areas. The population partially recovered through at least the mid-1900s, but experienced a second major decline during the 1950s-1970s. In the late 1970s, a second rebound began across much of the continent; the largest breeding populations (Canadian/U.S. interior, Atlantic Coast >80% of total) increased from approximately 32,000 pairs in the early 1970s to >226,000 pairs in the late 1990s. Comparison of historic and current records challenges the opinion that cormorants are currently overabundant, and suggests that perception of overabundance rests on socio-political rather than biological or ecological factors. For this species, and others that are seen as competitors with humans, limits of human tolerance (i.e. "social carrying capacity") are far narrower than those of biological carrying capacity. Because large numbers have been typical for cormorants historically, population targets based on fishery or other objectives derived from human values will likely be readily surpassed, require intensive management, and significantly depart from the concept of conserving birds in natural numbers and natural habitats. Although managing fish-eating birds to benefit fishery yields may increase some fish populations, this approach does not resolve or address the underlying problems causing current fish population declines across the continent, and is in direct conflict with current broad scale conservation initiatives. To ensure inclusion of cormorants and other fish-eating birds in these conservation plans, the avian conservation community must continue to press for programs based on ecosystem health and process that recognize humans, fish and cormorants as three components of a complex system driven by many species and dynamic interactions. *Received 11 July 2005, accepted 10 October 2005.*

Key words.—Double-crested Cormorant, historic populations, distribution, current abundance, conservation vs. management plans.

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INTRODUCTION

In May of 1604, Samuel de Champlain sailed along the southwest coast of Nova Scotia and visited several islands. One, "The Isle of Cormorants", west of Cape Sable, was "so named because of the infinite number of these birds of whose eggs we took a barrel full" (Champlain 1922). On his visit to the nearby Seal Island group, Champlain wrote "the abundance of birds of different kinds is so great that no one would believe it possible unless he had seen it-such as cormorants . . ." Though Champlain does not identify the species of cormorant he observed, Lewis (1929) concluded some of the birds were likely Double-crested Cormorants (*Phalacrocorax auritus*) (DCCO); more than 200 years after Champlain's visit, Audubon (1840-1844) reported Double-crested Cormorants breeding on the Seal Islands.

By the late 19th and early 20th centuries, however, the abundance of cormorants Champlain and others observed across much of North America had greatly diminished. As early as 1634, cormorants were reported "to destroy abundance of small fish" (Wood 1634); since this time, the perception of cormorant diet and foraging behavior has changed little and has been a significant factor affecting the distribution and abundance of the DCCO in North America. Human efforts to reduce numbers and eliminate populations have been documented throughout European settlement, and species history during the latter part of the 19th and the first quarter of the 20th centuries has been described as "a history of persecution and gradual abandonment of one breeding place after another" (Lewis 1929).

Between the 1920s-1940s, DCCOs began a period of population recovery and expansion in several areas. This period was relatively short-lived, however, as widespread use of DDT beginning in the 1940s, combined with legal and illegal control activities and habitat change, led to a second major period of DCCO population declines (e.g., Carter *et al.* 1995; Hatch 1995; Krohn *et al.* 1995; Ludwig *et al.* 1995; Weseloh *et al.* 1995). Between the late 1940s-1970s, numbers plummeted sharply across much of the species range.

Conversely, history of the species during the last third of the 20th century can be described as one of protection and conservation efforts. In 1972 the DCCO was Blue Listed by National Audubon Society (Tate and Tate 1982) and added to the U.S. Migratory Bird Treaty Act protected bird list (23 U.S.T. 260 (1972)). In the same year, DDT was also banned (U.S. EPA 1972). These actions, along with changes in the prey base (e.g., increases in forage fish in natural waters and development of large-scale aquaculture facilities) contributed to the recent period of spectacular growth in numbers and return of DCCOs to many portions of the historic range from which they had long been absent. Presently, the species is widespread and abundantly distributed with five major breeding regions described: Alaska, the Pacific Coast, Canadian and U.S. Interior, Gulf Coast, and Atlantic Coast (Hatch and Weseloh 1999; Wires *et al.* 2001).

In this paper, we identify conflicts between federal policy and continental/regional conservation plans that are closely linked to interpretations of recent population growth. Current DCCO numbers are reported to be at "all time" or "historic" highs (USDA/WS Activity/Fact sheet; USFWS News Release for DCCO Proposed Rule, Mar. 2003; Wywialowski 1999), and to have "irrupted" during the last 20 years (Glahn *et. al.* 2000). Though historical information is limited (Hatch 1995; Wires *et al.* 2001) the U.S. Fish and Wildlife Service (USFWS) Proposed Rule for DCCO (USDI/FWS 2003a) stated, "population levels are greater now than in the past." Additionally, the species is frequently characterized as "overabundant" (e.g., Farquhar 2001; USDA/APHIS/WS 2003; USFWS Waterbird Fact Sheet, Jan 2002). Growing concern over population changes and possible impacts to natural resources led USFWS, in conjunction with U.S. Dept. of Agriculture/Wildlife Services (USDA/WS), to prepare an Environmental Impact Statement (USDI/FWS 2003b), and publish a Final Rule which establishes a Public Resource Depredation Order for DCCOs effective in 24 states (geared towards Interior, Southeastern and Atlantic coast populations), and revises the 1998 DCCO Aquaculture Depredation Order to include lethal control at winter roost sites (USDI/FWS 2003c). At the same time, large-scale conservation plans for waterbirds in North America and Canada are based on sustaining and/or restoring waterbird populations throughout their historical range (Kushlan *et al.* 2002; Milko *et al.* 2003).

To provide a context for the abundance of current (1970-2000) populations we review historic (*circa* 1900 and earlier) populations of Double-crested Cormorants. Though human modification of the environment was well under way in the 19th century, human induced environmental change greatly accelerated in the 20th century and severely impacted many wildlife species (Askins 1999), including DCCOs (Hatch and Weseloh 1999). Therefore, we examine occurrence during the historic period because populations at this time were more representative of the numbers that existed under relatively "natural" conditions. We explore the concept of "overabundance" as it relates to distribution and abundance of cormorants, perceptions about cormorant population growth and recovery, and biological carrying capacity vs. "wildlife acceptance capacity". Because establishing population objectives is a goal for major bird conservation plans (e.g., Partners in Flight (Bonney *et al.* 1999), North American Waterbird Plan (Kushlan *et al.* 2002), North American Waterfowl Management Plan (NAWMP 1998), U.S. Shorebird Conservation Plan (Brown *et al.* 2001)), we also discuss factors that have influenced population objectives for cormorants.

METHODS

To describe historic (pre-1900) breeding distribution of DCCOs in North America, we reviewed early ornithological and archaeological records reported in journals, state breeding bird atlases, books and maps. All records that reported observations of nests, chicks and/or eggs were considered breeding records. Records that contained circumstantial or anecdotal evidence indicating cormorants may have been breeding were explored and considered probable breeding records based on factors such as long-term occurrence in area, season record was obtained, age of specimen seen, and author's comments and apparent level of knowledge. Records of breeding obtained post-1900 were included if they indicated the colony site was historic or had likely been occupied prior to 1900. Because most early records did not provide numerical estimates we were unable to estimate historic number of breeding birds on a regional level. However, early records often included qualitative descriptions of abundance and sometimes estimates of numbers of pairs or nests. We carefully examined these descriptions to obtain information on and assess historic abundance.

To describe current (1970-2000) breeding distribution and abundance, we obtained census and survey data from university, state and provincial biologists monitoring DCCOs across the continent. Most of these individuals and agencies regularly census DCCO colonies and they provided us with estimates of breeding pairs.

In an effort to present biologically relevant information for current and historic populations, we report population data in the context of distinct breeding zones. Hatch and Weseloh (1999) described five main breeding zones for DCCOs in North America: Alaska, Pacific Coast, Canadian and U.S. Interior, Florida and the western Caribbean, and the Atlantic Coast, which largely correspond to distribution of the five subspecies (Palmer 1962; Johnsgard 1993). Though thought to reflect fairly distinct breeding populations, recent expansion and re-colonization has blurred boundaries between and among these zones (Hatch and Weseloh 1999; Wires *et al.* 2001). Border states between Interior and Florida/Caribbean populations, Interior and Pacific Coast populations, and Florida/Caribbean and Atlantic Coast populations (e.g., Texas, New Mexico, Idaho, inland southern states, the Carolinas), qualify as "gray areas" or regions where it is not possible to identify precisely what zone breeding cormorants belong to without banding and molecular studies. To determine the most likely population zone for each colony documented prior to 1900 and between 1970-2000, we relied on subspecies distribution information and consideration of logical geographic units. Latitude/longitude coordinates were obtained for historic and current breeding sites and mapped within each breeding zone. For some historic sites, only general locations (e.g., county, central portion of state) were documented; for these sites, best approximate locations were mapped. Changes in abundance and distribution were examined by comparing current and historic records within each of the breeding zones.

RESULTS

Distribution

Archaeological records.—We did not conduct an exhaustive search for archeological records. Those we report were obtained while searching for early records and are based on skeletal remains retrieved from Native American middens. Though only four records were found, they indicate DCCOs were present in three of five breeding zones (Fig. 1) between 500-5000 years ago. Bones of young birds collected from middens on the Pacific and North Atlantic coasts indicate DCCOs were breeding on both coasts. Skeletal material retrieved from middens on Amchitka, Aleutian Islands, documents presence but does not verify breeding because no bones of young birds were found.

Early ornithological records (1500-1900).—Prior to 1900, cormorants were widely distributed across North America, and occurred in all five of the hypothesized breeding zones (Fig. 1). Approximately 80% of the locations shown are documented breeding sites (i.e., have records of nests, eggs, or young); we designated the remaining 20% as probable or possible breeding locations based on circumstantial or anecdotal information (e.g., time of year observed, author's comment). Systematic surveys for birds were not formalized at most locations prior to the twentieth century; thus, the number of records within each breeding zone does not

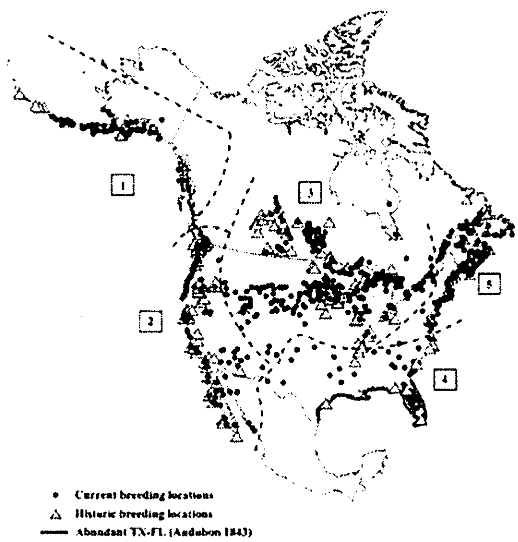

Figure 1. Historic (1900 and earlier) and current (1970-2000) breeding locations of the Double-crested Cormorant in North America. 1) Alaska; 2) Pacific Coast; 3) Canadian and U.S. Interior; 4) Southeast U.S./Caribbean; 5) Northeast Atlantic Coast.

reflect abundance of breeding birds or extent of distribution. In some areas (e.g., Pacific and Atlantic coasts), multiple records prior to 1900 are available; in others (e.g. some parts of the Interior and Gulf Coast), little effort was made to survey avifauna prior to the twentieth century (Ridgway 1874).

Current records (1970-2000).—In general, distribution of the current population is similar to that of the historic population (Fig. 1). All records shown are documented nest sites, and, with the exception of states and provinces for which data were not available, represent the continental breeding distribution. Important areas that appear different from historic distribution (Fig. 1) include the Great Lakes and western portion of the Interior range; interior portion of southeastern U.S.; and southeastern Alaska. Comparison of historic and current distribution maps suggests the species currently has a wider distribution in these zones.

Abundance

Historic abundance.—While precise counts are not available for most colonies prior to the twentieth century, records located for each population zone suggest historic populations of DCCO were very large. To indicate relative abundance within each population zone we summarized colony observations and qualitative descriptions for each breeding region (see Zone Summaries below).

Current abundance.—Census efforts among states and provinces are rarely coordinated across breeding zones due to several factors (e.g., limited funding, political boundaries). Therefore, colony size typically is not estimated during the same year or using the same census technique across a population. Additionally, some important areas that provide breeding habitat for large numbers of cormorants (e.g., Mexico, Manitoba) are not regularly censused and little is known about cormorants in major portions of these areas. Thus, accurate estimates for regional (zone-wide) populations are not available. However, most areas within the five breeding zones are regularly censused and estimates of breeding pairs are available for many colony sites. To indicate relative abundance of DCCOs in each population zone we report (Table 2) population estimates for each breeding region based on the most recent and complete census efforts.

Alaska Summary

Birds in this zone comprise the subspecies *P.a. cincinatus*, the most restricted (Palmer 1962) and smallest of the five populations. Between 1970 and 2000, DCCOs were confirmed nesting at 126 colonies, mostly along the southern coast and on the Aleutian Islands (Fig. 1). Alaska has not conducted statewide censuses of all colonies in the same year and the number of breeding birds is not known. However, 106 sites were censused at least once between 1970 and 2000; most colonies (93%) were small (<100 pairs), and a total of 3,029 pairs was reported (Table 2). Because so few data are available over such a broad time period it is not possible to comment on how closely this estimate approximates actual numbers, but the abundance of small colonies suggests the population is small.

Determining historic distribution and abundance in this zone is complicated by the large-scale introduction of foxes (*Alopex lagopus*; *Vulpes vulpes*) to Alaska that occurred between 1750 and the early 1900s (Bailey 1993). Because introduced foxes had major impacts on nesting seabirds (Bailey 1993; Carter 1995), records collected during the historic period may reflect a recently modified distribution and abundance. Turner (1885) described DCCOs as abundant residents and breeders in the Near Islands in the western Aleutians in the late 1800s, and Clark (1911) reported they were still present on these islands as breeders in the early 1900s. However, the peak in fur farming did not occur until the early 1900s, with the most rapid growth occurring in the 1920s (Bailey 1993); by the mid-1930s, DCCOs were no longer breeding in the Near Islands (Murie 1959). Today the western-most breeding point is Chuginidak, Aleutian Islands (52°51'04", 169°49'69").

Gabrielson and Lincoln (1959) note that reports of DCCOs breeding throughout southeastern Alaska could not be confirmed with available information. They reviewed early records up to 1945, and defined the breeding distribution "from Kodiak westward at suitable places along the Alaska Peninsula far out into the Aleutian Islands." All observed colonies were small (<100 pairs).

Based on available information, current DCCO distribution appears more restricted than in the past. In this portion of the range, DCCOs utilize level ground for nesting, which makes colonies vulnerable to terrestrial predators (Siegel-Causey *et al.* 1991). Introduction of foxes may have limited cormorant distribution, and if large colonies existed, they may have been substantially reduced before they were documented, particularly in the Aleutian Islands and Gulf of Alaska (Siegel-Causey *et al.* 1991; Carter *et al.* 1995). Murie (1959) noted a "drastic change" in the Alaska distribution since about 1906. Disappearance from portions of the range combined with increased predation pressure suggests DCCOs may have been more abundant historically, at least in parts of this region, than they are today. Additional causes that may have contributed to declines include other introduced predators and rabbits, and human disturbance (Siegel-Causey *et al.* 1991; Bailey 1993; Carter *et al.* 1995).

Pacific Coast Summary

Birds in this zone comprise the subspecies *P.a. albociliatus*. Between 1970 and 2000, nesting was documented at 248 sites (Table 2). The current breeding population occurs mostly along the coast from southern British Columbia to at least Bird Island, Sinaloa, Mexico (Fig. 2), and possibly further south (Carter *et al.* 1995). Significant colonies also occur inland. Summing available estimates for the late 1980s and 1990s, approximately 33,000 nesting pairs were documented in the region primarily during the mid-to-late 1990s. However, estimates from important portions of this region are dated, and large-scale movement among breeding birds occurs. In the Salton Sea, dramatic increases in breeding birds occurred during the mid-to-late 1990s, and cannot be attributed to productivity rates alone (D. Shuford, Point Reyes Bird Observatory (PRBO), pers. comm.); most birds were believed to be immigrants from other locations, possibly Mexico (D. Shuford, PRBO, pers. comm.). Because of large shifts and intercolony movement, frequent monitoring efforts over wide areas are required to estimate regional population size (Carter *et al.* 1995). Although data collection and census efforts have not been coordinated across the region, available information indicates this population is the third largest, but relatively small in comparison to the North Atlantic Coast and Interior populations.

With the exception of British Columbia, the DCCO was recorded as a breeding species throughout most of the Pacific Coast prior to 1900. The earliest breeding records we located were bones of young cormorants retrieved from a shell mound in Emeryville, CA. Samples from the mound indicate that aboriginal people utilized the area as long as 2,550 years ago and hunted a great diversity of waterbirds, including DCCOs (Howard 1929; Sher 1994; Broughton 2004). Although bones of DCCOs are abundant at archaeological sites throughout the Straits of Georgia, British Columbia, indicating the species occupied this area for the past 5,000 years, no skeletal remains of young birds were identified in excavations (Hobson and Driver 1989). Nesting was not documented in the province until 1927 (Munro 1928). However, based on archaeological evidence, Hobson and Driver (1989) suggest that the first documented nesting for this species may actually represent a re-colonization of the area.

Multiple records indicate breeding DCCOs were historically abundant across much of their Pacific Coast range (Squires 1917; Ray 1915; Chamberlin 1895; Willett 1910, 1933; Howell 1917; Grinnell 1908; Finley 1907, 1915; Linton 1907; Lamb and Howell 1913; Goldman 1908; Salvadori 1865; Lamb 1927; Bryant 1889; Bancroft 1927b; Bendire 1877; Dawson 1908, 1911). The largest cormorant colony ever recorded on the continent existed at San Martin Island, Baja California, MX; Wright (1913) estimated 348,840 nests at this site. The estimated size of this colony alone is larger than each of the five current regional populations and may be comparable to current continental population size. Although Wright's estimate was later considered an overestimate and revised by J. R. Jehl to 213,500 pairs (Hatch 1995) based on the area of the island, the revised estimate still dwarfs the present size of the entire Pacific Coast and much of the North American population. Even if Jehl's estimate is off by an order of magnitude, no colony approaches this size anywhere in North America.

By the late 1800s and early 1900s, the DCCO had experienced substantial decline and loss of breeding colonies along several portions of its Pacific Coast range. The species was heavily persecuted by humans, and breeding birds were shot at colonies and nests destroyed. In addition, habitat was lost due to agricultural and water developments (Carter *et al.* 1995). Review of early records suggests that the DCCO was far more abundant in this zone historically than it is today.

Interior Summary

Birds in this zone represent a substantial portion of *P.a. auritus*' distribution. Between 1970 and 2000, nesting was reported at 704-754 sites (Table 2). This is the largest, most widespread breeding population; it spans the prairie provinces of Canada, the Canadian and U.S. Great Lakes, and southwestern Quebec. The distribution extends west of Minnesota to southwestern Idaho, and as far south as central Utah and central Colorado. Local breeding also occurs in central Kansas and possibly northern New Mexico. Breeding birds in Idaho were included in this zone based on Burleigh (1972), who reported that 11 specimens collected from different locations in Idaho were intermediate in their characters between *P.a. auritus* and *P.a. albociliatus*, but closer to *auritus*. Birds breeding in the Upper Rio Grande drainage and Middle Pecos River, New Mexico, were also included in this zone, based on plumage characters of *P.a. auritus* (S. Williams, NM Dept. Game and Fish, pers. comm.). Genetic analyses need to be undertaken to confirm these subspecies designations.

Recent estimates based on complete counts are available for about half the states and provinces where cormorants breed. With the exception of Manitoba, complete counts are available for most of the areas where cormorants nest in large numbers. The largest numbers occur in the Great Lakes and Prairie Provinces. Summing the most recent estimates available for each state and province gives a very rough estimate of 170,000 pairs for the region in the 1990s (Table 2). However, the breeding population is significantly larger than this. Recent estimates are not available for some areas, and several estimates for other areas were based on partial counts. With the exception of Manitoba, DCCOs are not known to breed in very large numbers (several thousands) in most portions of the Interior range where estimates were missing or incomplete (Hatch 1995, Wires *et al.* 2001). In Manitoba, however, DCCOs do breed in large numbers, particularly on Lake Winnipegosis. The last province-wide survey was conducted in 1979, at which time 22,642 active nests were documented; 9,053 nests were on Lake Winnipegosis, an extremely important area for waterbird nesting (Koonz and Rakowski

1985). The last census of Lake Winnipegosis in 1999 indicated pairs of nesting cormorants had quadrupled since the previous survey 20 years earlier (Table 2). Assuming cormorant numbers across Manitoba increased at the same rate, there may be as many as 90,000 pairs in Manitoba province-wide (W. Koonz, Manitoba Dept. Nat. Res., pers. comm.). Given these gaps, the Interior population in the late 1990s may have been closer to 270,000 pairs but the accuracy of this estimate is unknown.

In many parts of the Interior region, the early breeding history of the DCCO is well known. Pre-1900 records document nesting by the species across most of the region and suggest it had been a long-time and abundant breeder in several areas, particularly in the Prairie Provinces and the mid-western states, where many large colonies were documented. In Minnesota, Hatch (1892) reported DCCOs bred in nearly all parts of the state, and was "occasional to innumerable" depending on how close one was to breeding colonies. At the Minnesota-Iowa border, observers reported "the air is jist black with em' an they're nestin' on the island so yer can't see it for eggs" (Whitehead 1887). In Missouri, Widmann (1907) reported cormorants breeding in "considerable numbers." In Ohio, "boatloads" were killed at St. Mary's Reservoir (Langdon 1878). At Lake of the Woods, Ontario, "great numbers" of young were killed in the late 1700s (Tanner 1994). Lakes Winnipeg and Winnipegosis, Manitoba, have long been recognized for their very large colonies (Seton 1886; Bent 1922). Lake Isle a la Crosse, Saskatchewan, also had a "large" regular breeding colony (Seton 1908). For additional records see Barnes 1890; Cooke 1888; Roberts 1932; Agersborg 1885; Stansbury 1853.

The Great Lakes is the one area within the region where status (e.g., breeder or migrant) and early history of the cormorant are not clear. For example, investigators reported that DCCOs colonized and invaded the Great Lakes in the early 20[th] century, moving in an easterly direction after the first nesting was reported on western Lake Superior in 1913 (Postupalsky 1978; Weseloh and Collier 1995). However, records and other evidence indicate DCCOs were present in the area prior to the 20[th] century, suggesting this portion of the cormorant's North American range was occupied earlier than 1913, and possibly breeding. These records and evidence, described below, fall into the following categories: anecdotal, geographic place names, and general breeding distribution.

In the first category, three anecdotal records are important in presumed colonization history. The earliest reported observation of cormorants breeding at a specific location on the Great Lakes proper is an anecdotal record; Postupalsky (1978) cites a personal communication from Frank Novy that cormorants were breeding in the Great Lakes on western Lake Superior in 1913. No additional information is available about this record. However, because no other records were known at the time of Postupalsky's publication, this 1913 personal communication is regarded as the first nesting of cormorants in the Great Lakes. Additionally, the order in which the Great Lakes were hypothetically colonized is traced to it (Postupalsky 1978; Weseloh and Collier 1995). The first documented account of cormorants nesting on the Great Lakes proper is reported in Fargo and Van Tyne (1927). This record reports discovery of a small colony (10 nests) in 1926 at Agawa Rocks, Agawa Bay, on the eastern shore of Lake Superior. However, Fargo and Van Tyne noted that local residents told them "the cormorants had nested there for years." No additional information is available about this colony, but this anecdotal information suggests cormorants had a history of breeding in the area prior to discovery of the colony. A third record (Baillie 1947) from Georgian Bay, Lake Huron, reports that cormorants were nesting in the general vicinity of the Mink Islands in 1919; though this record was never verified, based on other nesting records, Baillie (1947) believed the record was probably accurate. This record places breeding cormorants much farther east into the Great Lakes more than a decade earlier than was hypothesized by Postupalsky (1978) and Weseloh and Collier (1995).

In the second category, geographic place names suggest cormorants were present in the area and recognized by both Native Americans and settlers, but their status as breeders or migrants is not reported. The earliest of these place names is found on a General Surveyors Office Plat Map of Forsyth Township, Michigan. On 4 Aug, 1854, this map was signed and filed in the General Land Office in Detroit, and documents the existence of two lakes, Shag Lake and Little Shag Lake. Shag, a common vernacular name for cormorant, suggests cormorants were present in the area when the map was prepared. These lakes still exist and are located in the upper peninsula in Marquette Co, about 8-16 km from Lake Superior and within 64 km of Lake Michigan, Bay de Noc area, where cormorants are currently abundant. The map survey work was done during the third quarter (July-Sept) of 1844, and further subdivisions of the township were completed during the third and fourth (Oct-Dec) quarters of 1852. Thus cormorants occurred in the area during the summer and or fall months but their status (breeder, migrant) is unknown. The second geographic place name is from Lake Onaping, Ontario, about 64 km north of the North Channel, Georgian Bay area (Bell 1891). At this location a rock forming part of the cliffs on the west side of the lake was named by the Ojibwa "Kakakeshiwishtagwaning", which means "the cormorant's head", and suggests that the Ojibwa were familiar with cormorants in this landscape.

In the third category, the first four editions of the Checklist of North American Birds (1886, 1895, 1910 and 1931) all report the Great Lakes as part of the breeding range of the DCCO but give no specific locations within the lakes. These records indicate cormorants were breeding in the Great Lakes region earlier than 1913, but because specific locales are not provided it is not possible to determine if cormorants nested on the Great Lakes proper, or on nearby inland lakes. An additional record reports capture of a cormorant in June, 1877, at Sandusky Bay, OH (Wheaton 1882). No other information is available about this record, but the presence of a cormorant at this time of year suggests the bird may have been breeding.

As occurred over much of the continental range, DCCOs in the interior underwent substantial declines in the late 1800s and early 1900s. Persistent human persecution and habitat degradation resulted in colony declines, abandonment and local extirpation from several states (e.g., South Dakota, Indiana, Ohio, Missouri, Iowa, Illinois, Arkansas) (Lewis 1929). Because so few estimates are available pre-1900 and data vary greatly among states and provinces, it is not possible to determine if cormorants were more abundant historically in this zone than they are today. For some areas (e.g., Indiana, Ohio, Iowa, Arkansas, Illinois, Minnesota, Missouri) available data suggest breeding cormorants were more abundant historically. Additionally, very large migrant flocks were observed that were much larger than those currently known to pass through the region. In Minnesota, a flock of migrating cormorants was described that was "four miles long and one-and-a-half miles wide" (Sennett 1891). Though numbers declined throughout much of the Interior by the turn of the century, large numbers were still occasionally observed; in 1926, a flock estimated at 100,000 to one million individuals was described migrating up the Mississippi River past LaCrosse, and was so large "that at times it was impossible to see the sunset sky through the mass" (Grassett 1926). During recent years (1970-2000), no flocks anywhere near this size have been reported.

In other areas of this zone (e.g., the Great Lakes), current numbers are much greater than they were in the late 1800s-early 1900s, and are the highest recorded in the history of the region. In the Prairie Provinces, cormorants were historically and are currently abundant, but it is not possible to determine if abundance has greatly changed.

Southeast U.S. and Caribbean

Birds breeding along the Gulf Coast, the south Atlantic Coast, and in the Caribbean comprise the subspecies *P.a. floridanus*, while birds breeding in the Bahamas and Cuba are classified as *P.a. heuretus* (Hatch and Weseloh 1999). This breeding zone extends from southern and central Texas to Florida, and along the Atlantic Coast through Florida, Georgia, and the Carolinas. Birds breeding in southern Texas and southwestern Arkansas were included in this zone based on subspecies distribution maps (Palmer 1962; Johnsgard 1993). Because North Carolina has been reported as the northern breeding limit for *P.a. floridanus* (Audubon 1840-1844; Bent 1922; Johnsgard 1993), and other authors have suggested that Carolina birds may comprise this subspecies (Palmer 1962; Clapp and Buckley 1984; Post and Post 1988), we included birds breeding in the Carolinas as part of the Southeastern U.S./ Caribbean zone. Recent estimates based on complete counts are available for most of the known colonies, with the exception of southern Texas, the Yucatan and the Caribbean. The largest known numbers occur in Florida. Summing estimates available for the region in the 1990s gives an approximate estimate of 9,400 pairs at >108 sites (Table 2).

Prior to the 20th century, the DCCO was "constantly resident in the Floridas and their Keys, and along the coast to Texas" (Audubon 1840-1844). Breeding was recorded in North Carolina as early as the 18th century; at that time cormorants were reported to "lay their eggs in . . . the Islands, in the Sound and near the Sea Shoar in the Banks, and sometimes on high trees, as the Shags do" (Brickell 1737). Several records document breeding along both the Gulf and Atlantic coasts (Table 1).

Although no quantitative data were located to provide a comparison between current and historic abundance, descriptions suggest breeding cormorants were more abundant in this zone prior to the 20th century than they are today. Presently, breeding cormorants are only abundant in Florida (Wires *et al.* 2001), while historically they were very numerous in multiple areas of the region. Audubon (1843) reported "many thousands" breeding in the Florida Keys in 1832; Bricknell (1737) stated that in North Carolina, they were "as numerous all over these Parts of America as in any part of the World"; Audubon (1843) and Beyer *et al.* (1907) described cormorants as "abundant" in the Louisiana interior and on the coast; and Howell (1911) reported this species as "formerly abundant in the rivers and swamps of eastern Arkansas". Additionally, based on Audubon's (1840-1844) description, DCCOs may have been present as breeders along the Alabama, Mississippi and Texas coasts.

Northeast Atlantic Coast

Birds in this zone are also placed in the subspecies *P.a. auritus*, and breed along the Atlantic Coast from southern Newfoundland, the northern shore of the Gulf and estuary of the St. Lawrence River, Anticosti Island, Magdalen Island, south along the coast to New York City and Long Island (Hatch and Weseloh 1999). The range is expanding south with recent breeding and re-colonization in New Jersey, Delaware, Maryland and Virginia, as far south as Hopewell. Recent estimates based on complete counts are available for nearly all colonies known to be active in this region, with the exception of New Brunswick (Table 2). The largest numbers occur in Quebec in the St. Lawrence River, Estuary and Gulf, along the coast of Maine, and in the Maritime Provinces. Summing estimates available for the region in the 1990s gives an approximate estimate of 87,000 breeding pairs at 381-382 sites. This number should be interpreted cautiously because intercolony movement is common and the size of individual colonies may change dramatically from year to year in substantial portions of the region (J. F. Rail, Canadian Wildlife Service (CWS), pers. comm.). Additionally, a culling program in the St. Lawrence River in 1989 significantly reduced numbers in Quebec in the 1990s.

Archaeological records document cormorants as a breeding species in this zone from the late prehistoric period (about 1500 AD) (Luedtke 1980). Several historic records report breeding from the Straits of Belle Isle, northwest coast of the Island of Newfoundland, south to as far as Boston Harbor, Massachusettes (Table 1). The historic breeding distribution may have extended further south; Mendall (1936) notes that Williams' (1643) observations of Native American use

Table 1. Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

Region	Site	Early Date (bp = before present)	Status	Latitude	Longitude	Source
Zone 1 Alaska						
AK	Amchitka	2,650 bp	B	51°32'	179°00'	Siegel-Causey *et al.* 1999
AK	W. Aleutians, Nearer I., Attu	prior to 1885	B	52°54'09"	172°54'34"	Turner 1885; Clark 1911
AK	W. Aleutians, Nearer I., Agattu	prior to 1885	B	52°26'07"	173°34'32"	Turner 1885; Clark 1911
AK	Atka	1906	PB	52°08'17"	174°26'43"	Clark 1911
AK	Unalga Pass	1906	PB	53°57'04"	166°12'18"	Clark 1911
AK	Iliamna Lake	1902	B	59°39'12"	154°41'28"	Gabrielson and Lincoln 1959
AK	Kodiak	1843	PB	57°23'46"	153°29'00"	Gabrielson and Lincoln 1959
Zone 2 Pacific Coast						
AZ	Tucson	1897	PB	32°13'18"	110°55'33"	Phillips *et al.* 1964
B.C.	Vancouver I, Central E. coast	1500 BC-400 AD	PB	49°19'30"	124°17'30"	Hobson & Driver 1989
B.C.	Gulf I, Active Pass	3500 BC-1800 AD	PB	48°51'25"	123°20'00"	Hobson & Driver 1989
B.C.	S. Vancouver I.	500-1000 AD	PB	48°26'05"	123°26'53"	Hobson & Driver 1989
B.C.	Boundary Bay/Fraser River	1500 BC-400AD	PB	49°01'48"	123°03'55"	Hobson & Driver 1989
B.C.	Fraser River	2300BC-1000AD	PB	49°09'30"	122°56'25"	Hobson & Driver 1989
B.C.	Bare Island (Mandarti I.)	1927	B	48°38'00"	123°17'00"	Munro 1928
CA	Emeryville Shell Mound	550 BC-1770 AD	B	37°49'53"	122°17'03"	Howard 1929; Sher 1994
CA	S. Farallon I.	mid-1800s	B	37°42'00"	123°00'00"	Bryant 1888; Dawson 1911
CA	Seal Rocks San Francisco	prior to 1917	B	37°46'42"	122°30'53"	Squires 1917
CA	Eagle Lake	1914	B	40°38'42"	120°44'34"	Ray 1915
CA	Clear Lake, Lake Co.	1895	B	39°03'42"	122°49'34"	Chamberlin 1895
CA	Clear Lake, Modoc Co.	1918	B	41°16'32"	120°16'33"	Willett 1919
CA	Santa Barbara I.	1897	B	33°28'32"	119°02'07"	Howell 1917; Willett 1933
CA	Anacapa (Santa Barbara group)	1910	B	34°00'16"	119°23'55"	Willett 1910; Howell 1917
CA	Prince I. (0.5 mile from San Miguel I)	1910	B	34°03'29"	120°19'57"	Willett 1910; Howell 1917
CA	Santa Cruz I.	1895	B	34°01'00"	119°43'00"	Howell 1917
CA	Lake Henshaw, San Diego Co.	prior to 1933	B	33°14'30"	116°45'44"	Willett 1933
CA	Pelican Island, Salton Sea	1908	B	33°20'00"	115°50'00"	Grinnell 1908
CA	Tule Lake (CA/OR border)	1895	B	41°54'34"	121°31'55"	Finley 1907
CA	Island in (Lower) Klamath Lake Resv.	1912	B	41°58'22"	121°47'45"	Finley 1912
CA	Klamath Lake, Lower	1915	B	41°58'22"	121°47'45"	Finley 1915
CA	Rattlesnake I (Tule Lake)	1895	B	39°00'36"	122°40'44"	Finley 1907

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

Region	Site	Early Date (bp = before present)	Status	Latitude	Longitude	Source
CA	Butte Creek, Sutter Co.	prior to 1926	B	39°11'41"	121°56'07"	Moffitt 1939
CA	Cut-off Slough, S of Suisan	1920	B	38°05'25"	122°00'33"	Moffitt 1939
CA	Buena Vista Lake, Kern Co.	1907	B	35°11'31"	119°17'37"	Linton 1907
CA	Buena Vista Lake, Kern Co. (Pelican I.)	1912	B	35°12'39"	119°16'03"	Lamb and Howell 1913
CA	Tulare Lake	1907	B	36°08'20"	119°43'28"	Goldman 1908
MX	Natividad I.	1865; 1924	B	27°54'30"	115°13'00"	Salvadori 1865; Lamb 1927
MX	Cerros I. (Isla Cedros)	prior to 1889	B	28°03'	115°20'	Bryant 1889
MX	Magdalena Bay	1889	B	25°00'	112°20'	Bryant 1889
MX	Santa Margarita Island	1889	B	24°30'	112°10'	Bryant 1889
MX	Cape St. Lucas, Lower CA	1859	PB	23°00'	82°20'	Baird 1859
MX	San Roque I., w. coast BC	1927	B	27°09'30"	114°22'30"	Huey 1927
MX	Gulf, near San Jose Island	1902	B	25°00'	110°40'	Brewster 1902
MX	Scammons Lagoon	1926	B	28°20'	114°22'	Bancroft 1927(a,b)
MX	Los Coronados	mid-1920s	B	32°25'30"	117°15'30"	Bancroft 1927(b)
MX	Todos Santos	mid-1920s	B	31°47'00"	116°46'00"	Bancroft 1927(b)
MX	San Luis I., central Gulf. BC	mid-1920s	B	29°58'00"	114°26'00"	Bancroft 1927(b)
MX	San Martin I., LC	1913	B	30°29'30"	116°06'30"	Wright 1913
OR	Columbia river mouth*	1805	PB	46°13'20"	123°49'22"	Lewis and Clark 1814
OR	Fort Klamath	1886-1887	PB	42°41'37"	121°58'10"	Merrill 1888
OR	Williamson's River	1886-1887	PB	42°27'54"	121°57'21"	Merrill 1888
OR	Diamond Lake	1886-1887	PB	43°09'32"	122°08'59"	Merrill 1888
OR	Camp Harney	1875	B	43°38'36"	118°49'18"	Bendire 1877
OR	Malheur Lake	1875, 1918	B	43°21'20"	118°41'56"	Bendire 1878; Willett 1919
OR	Three Arch Rocks	1901	B	45°27'51"	123°59'12"	Finley 1902, 1905
OR	Sylvies River	1877	B	44°00'01"	118°55'37"	Bendire 1878
WA	Olympic Peninsula Outer coast, "Olympiades"					
	Erin's Bride	1905-1907	B	47°18'	124°16'	Dawson 1908
	The Grenville Arch	1905-1907	B	47°18'20"	124°17'	Dawson 1908
	The Grenville Pillar	1905-1907	B	47°18'20"	124°17'	Dawson 1908
	Split Rock	1905-1907	B	47°24'20"	124°21'45"	Dawson 1908
	Willoughby Rock	1905-1907	B	47°24'40"	124°21'22"	Dawson 1908
	Destruction Island	1905-1907	B	47°40'20"	124°30'	Dawson 1908
	North Rock	1905-1907	B	47°44'45"	124°29'50"	Dawson 1908

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

Region	Site	Early Date (bp = before present)	Status	Latitude	Longitude	Source
	The Giants' Graveyard	1905-1907	B	47°50'30"	124°34'	Dawson 1908
	Dohodaaluh	1905-1907	B	47°57'	124°41'	Dawson 1908
	Carroll Islet	1905-1907	B	48°10'	124°43'30"	Dawson 1908
	Father and Son	1905-1907	B	48°13'50"	125°43'	Dawson 1908
WA	Jagged I.	1915	B	47°59'51"	124°41'39"	Cantwell, in Jewett *et al.* 1953
WA	Arched Rock	1915	B	na	na	Cantwell, in Jewett *et al.* 1953
WA	Alexander I.	1914	B	47°47'55"	124°30'19"	Cantwell, in Jewett *et al.* 1953
Zone 3 Interior						
AB	Buffalo Lake	prior to 1909	B	52°09'	112°09'	Macoun and Macoun 1909
AB	Ministik Lake	Early 20th	B	53°21'00"	113°01'00"	Salt and Wilk 1958
AB	Miquelon Lake	Early 20th	B	53°15'00"	112°53'00"	Lewis 1929; Salt and Wilk 1958
AB	Lac la Biche	Early 20th	B	54°46'00"	111°58'00"	Lewis 1929; Salt and Wilk 1958
AB	Therein Lakes	Early 20th	B	54°05'	111°30'	Lewis 1929
AB	Primrose Lake	Early 20th	B	54°48'00"	110°00'00"	Lewis 1929
IL	Mt. Carmel	Late 1800s	B	38°24'39"	87°45'41"	Ridgway 1874
IL	Lacon	prior to 1890	B	41°01'30"	89°22'16"	Barnes 1890
IL	5 miles N of Marshall Co.*	1890	B	41°11'06"	89°23'47"	Barnes 1890
IL	Marshall Co.*	1890	B	na	na	Barnes 1890
IL	Peoria	Late 1800s	B	40°43'59"	89°34'04"	Loucks 1893
IL	Havana (Il river area)*	1910	B	40°17'45"	90°03'15"	Smith 1911
IL	Clear Lake (Il river area)*	1910	B	40°25'35"	89°55'35"	Smith 1911
IN	Gibson Co.*	prior to 1900	PB	38°21'19"	87°34'03"	Mumford and Keller 1984
IN	Knox Co.*	prior to 1900	PB	38°37'57"	87°31'56"	Mumford and Keller 1984
IN/IL	Wabash River Valley*	1870s	B	na	na	Ridgway 1874
IN	Posey Co.*	prior to 1900	PB	37°49'13"	87°57'15"	Mumford and Keller 1984
IA	Northern IA*	1880s or earlier	B	43°09'	93°23'	Cooke 1888
MB	Shoal Lake	1886-1901	B	50°30'	100°00'	Seton 1886; Chapman 1902; Macoun and Macoun 1909
MB	Lake Winnipegosis	Prior to 1900	B	52°30'	100°00'	Seton 1886; Koonz and Rakowski 1985; Bent 1922
MB	Lake Winnipeg	1886	PB	52°07'55"	97°15'40"	Seton 1886; Macoun and Macoun 1909
MB	Lakes N. of Touchwood Hills	Early 1900s?	B	54°28'45"	94°59'46"	Lewis 1929
MB	Ossowa	Early 1900s?	B	unknown	unknown	Lewis 1929
MB	Selkirk Settlement	Early 1900s?	B	50°09'	96°52'	Lewis 1929

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

Region	Site	Early Date (bp = before present)	Status	Latitude	Longitude	Source
MI	Shag Lake, Marquette Co.	1854	PB	46°16'06"	87°30'27"	General Surveyors' Office Plat Map. Forsyth Township, MI (Township 45 N, Range 26 W.)
MI	Little Shag Lake, Marquette Co.	1854	PB	46°15'30"	87°29'41"	General Surveyors' Office Plat Map. Forsyth Township, MI (Township 45 N, Range 26 W)
MN	Lake Minnetonka	1860s-1875	B	42°52'	93°34'	Hatch 1892; Roberts 1932
MN	Loon Lake	1886	B	43°31'	95°11'	Whitehead 1887; Roberts 1932
MN	Kawishiwi Lake	Early 1900s	B	47°50'45"	91°06'50"	Roberts 1932
MN	Gull Rock, Lake of the Woods	1915	B	49°15'14"	94°53'08"	Roberts 1932
MN	Elbow Lake	prior to 1925	B	46°00'	95°59'	Lewis 1929
MN	Lake Shetack (Shetek)	1877	B	44°06'56"	95°41'34"	Hatch 1892; Lewis 1929
MN	Dead Lake	1885	B	46°28'	96°00'	Hatch 1892; Lewis 1929
MN	Heron Lake	prior to 1925	B	43°44'	95°20'	Lewis 1929
MN	Lake Andrew	prior to 1925	B	45°49'20"	95°25'15"	Lewis 1929
MN	Lanesboro	1883	B	43°43'	91°59'	Hatch 1892; Lewis 1929
MN	Faribault	prior to 1925	B	44°19'	93°16'	Lewis 1929
MO	S.E. peninsula, MS Lowlands*	prior to 1907	B	37°00'01"	90°01'05"	Widmann 1907
NE	Engineer Cantonment Area*	1820	PB	41°27'18"	96°00'50"	Thwaites 1905 (in Ducey 2000)
ND	Sweetwater Lake, Ramsey Co.	1897	B	48°13'00"	98°49'20"	Jacobs 1898 (in Stewart 1975)
ND	Devils Lake, Bird I.	1898	B	48°01'41"	98°55'52"	Job 1898; Rolfe 1898
ND	Stump Lake, Nelson Co.	1898	B	47°54'40"	98°23'02"	Job 1898; Rolfe 1898
OH	Licking Reservoir, Buckeye Lake, Liebs & adjacent islands	prior to 1880	B	39°54'26"	82°31'23"	Wheaton 1882; Trautman 1940; Peterjohn 1989
OH	Lake St. Mary's	1867	B	40°31'17"	84°25'17"	Langdon 1878 (Dury pers. Comm.)
OH	Sandusky Bay	prior to 1877	PB	41°28'38"	82°43'11"	Wheaton 1882
ONT	Lake of the Woods	1798	B	49°30'20"	94°50'30"	Tanner 1994
ONT	The Cormorant's Head, Onaping Lake	1890	PB	47°04'00"	81°30'00"	Bell 1891
ONT	Mink Islands, Georgian Bay, Lk. Huron*	1919	PB	45°22'00"	80°25'00"	Baillie 1947
ONT	Carney Rocks, Black Bay, Lk. Superior*	1920	B	48°40'00"	88°25'00"	Baillie 1947
ONT	Agawa Rocks (Bay), Lk. Superior*	1920s or earlier	B	47°20'00"	84°40'00"	Fargo and Van Tyne 1927
QUE	Way Rock, James Bay	1912	B	51°50'	78°59'	Todd 1963
SK	Qu'Appelle	1886	B	50°10'	103°50'	Seton 1886
SK	Saskatchewan River	1834	B	53°12'	105°46'	Audubon 1843
SK	Crane Lake	1894	B	50°05'00"	109°05'00"	Macoun and Macoun 1909
SK	Prince Albert	1890s or earlier	B	53°57'00"	106°22'00"	Macoun and Macoun 1909

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

Region	Site	Early Date (bp = before present)	Status	Latitude	Longitude	Source
SK	Big Stick Lake	1890s or earlier	B	50°16'00"	109°20'00"	Macoun and Macoun 1909
SK	Old Wives Lake	1890s or earlier	B	50°06'00"	106°00'00"	Macoun and Macoun 1909
SK	Stony Lake/Rocky Lake	1924	B	53°29'	108°32'	Mitchell 1925
SK	Suggi Lake	1910	B	54°20'	102°50'	McInnes 1913
SK	Basin Lake	1902	B	52°38'00"	105°17'00"	R. Congdon (Roney, pers. comm.); Lewis 1929
SK	Lake Isle a la Crosse	1907	B	56°	108°	Seton 1908
SD	Clay Co. area*	prior to 1885	B	42°43'52"	96°53'26"	Agersborg 1885
UT	Egg Island, Great Salt Lake	1849	B	41°03'35"	112°15'47"	Stansbury 1853
UT	White Rock, Great Salt Lake	1901	B	41°00'30"	112°14'52"	Hayward *et al.* 1976
WI	Northern and central lakes*	1890	B	45°27'	89°44'	Carr 1890
Zone 4 Southeastern U.S./Caribbean						
AR	Walker Lake, MS Co.	1910 and prior	B	35°45'24"	90°03'21"	Howell 1911
AR	Old Town Lake, Phillips Co.	1913	PB	34°24'30"	90°48'50"	James and Neal 1986
FL	Resident, both coasts*	prior to 1900	B	na	na	Audubon 1843; Bent 1922
FL	Florida Keys*	1832	B	na	na	Audubon 1843
FL	Gainesville	1894	B	29°39'05"	82°19'30"	Stevenson and Anderson 1994
FL	Wakulla River (at St. Marks)	1887, 1889	B	30°08'57"	84°12'38"	Pennock 1889
FL	Cuthbert Lake	1903	B	25°12'21"	80°46'41"	Bent 1922
KY	Hickman, Fulton Co.	1890-1893	PB	36°34'16"	89°11'10"	Pindar 1925
LA	Coast*	1830s	B	na	na	Audubon 1843; Beyer *et al.* 1907
LA	Interior*	1906	B	na	na	Beyer *et al.* 1907; LA Dept. of Cons. 1931
NC	"The islands, banks, sound"*	1737	B	35°15'	76°25'	Brickell 1737
NC	Great Lake ("Big Lake")	1898	B	34°52'06"	77°02'18"	Pearson 1899
SC	"Nests somewhere in state"	1910	PB	na	na	Wayne 1910
TN	Reelfoot Lake	late 1800s	PB	36°21'54"	89°24'13"	Rhoads 1895; Pindar 1925
TX	"Along the coast to TX"*	1840s	PB	na	na	Audubon 1843
TX	Matagorda peninsula & nearby island	1926	B	28°35'05"	96°01'05"	Oberholser 1974
Zone 5 Northeast Atlantic Coast						
CAN/ GNLD	Baffin Bay	1800s	B	na	na	Audubon 1843
LB	Northwest River, Lake Melville	prior to 1900	PB	53°40'	60°10'	Lewis 1929
ME	SW Coast (Monhegan I. area)	1614	PB	43°45'59"	69°18'43"	Smith 1616 (in Mendall 1936)

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

Region	Site	Early Date (bp = before present)	Status	Latitude	Longitude	Source
ME	Black Point (now Scarborough)	late 17th	B	43°34'41"	70°19'20"	Mendall 1936
ME	Black Horse Ledge	1895	B	44°03'	68°37'	Knight 1908
MA	Calf I., Boston Harbor	1500	B	42°20'30"	70°53'46"	Luedtke 1980
MA/RI:	no specific location	1643	B	na	na	Williams 1643 (in Mendall 1936)
NB	Grand Menan	1871-1872	PB	44°40'	66°50'	Herrick 1873
NF	Cormorant I.	1833	B	51°30'	57°00'	Audubon 1843
NF	St. George Bay, W.coast	1594	PB	48°20'	59°00'	Hakluyt 1904; Lewis 1929
NF	Hawk's Bay	1800s	B	50°35'	57°10'	Reeks 1869
NS	Isle of Cormorants, present Green I.	1604	B	43°26'00"	65°38'00"	Champlain 1922; Lewis 1929
NS	Seal Islands	1833	B	44°37'	65°46'	Audubon 1843
NS	Mud I. Group	1604	PB	43°25'	66°01'	Champlain 1922; Lewis 1929
NS	Cape Breton	1610	PB	45°48'	59°50'	Jesuit Relations 1896; Lewis 1929
QUE	Whapatiguan Harbour	1833	B	50°20'	60°20'	Audubon 1843
QUE	Magdalen I., I of Cormorants (Shag I.)	1591	PB	47°27'	61°30'	Hakluyt 1904; Lewis 1929
QUE	Sloop Harbor (now Whale Head)	1860	PB	50°30'00"	59°29'00"	Coues 1861
QUE	Harrington Harbor	prior to 1929	B	50°25'	59°30'	Lewis 1929
QUE	Bird Bay (E. end of Anticosti I)	1902, 1904	B	49°15'	61°45'	Schmitt 1902
QUE	Seal Rocks, off St. Genevieve I.	1909	B	50°20'	63°00'	Townsend and Bent 1910
QUE	Cormorant Isle, off Watachoo	1909	B	50°30'	62°30'	Townsend and Bent 1910
QUE	Bonaventure I., Gaspe Co., Perce Rocks	1880	B	48°30'	64°10'	Goss 1889
QUE	Harbour of Great Mecatina	1833	B	50°50'	58°55'	Audubon 1843
QUE	Rocky island off Agwanus	1909	B	50°15'	62°10'	Townsend and Bent 1910
QUE	Outer Islands, Coacoacho Bay	1915	B	50°20'	60°20'	Townsend 1917
QUE	Gull I., off Cape Whittle	1915	B	50°20'	60°10'	Townsend 1917

Table 2. Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

Regions of documented breeding	No. known colonies since @1970	No. pairs last census	No. colonies last census	Year of last census	Source (data are unpublished, obtained through personal communications unless otherwise noted)	Estimate quality	% known active colonies visited
Zone 1 Alaska							
Alaska	126	3029	106	1970-2000	Carter *et al.* 1995; D. Dragoo and S. Stephenson, USFWS	B	NA
Subtotals	126	3,029	106				
Zone 2 Pacific Coast							
Arizona	12	35	2	2000	T. Corman, Arizona Game and Fish Department	B	17
British Columbia	19	610	19	2000	I. Moul, Ecological Research Ltd.	A	100
California							
N. Coast, N. Section	17	1,408	14	1989	Carter *et al.* 1995	A	100
N. Coast, S. Section	4	75	3	1995	Carter *et al.* 1996, 2000	A	100
Central Coast-Outer Coast N	3	413	1	1995	Carter *et al.* 1996, 2000	A	100
Central Coast-San Francisco Bay	9	1,429	9	1990	Carter *et al.* 1995	A	100
Central Coast-Outer Coast S	6	198	6	1989	Carter *et al.* 1995	A	100
Southern Coast	6	1,264	6	1991	Carter *et al.* 1995	A	100
Interior	52	6,958	33	1999	Dave Shuford, Point Reyes Bird Obs.	A	100
Mexico							
Baja California	20	3,394	20	1968-1992	Carter *et al.* 1995	B	100
Sonora & Sinaloa	7	3,575	7	1973-1991	Carter *et al.* 1995	B	100
Interior	2	301	2	1990-1992	Carter *et al.* 1995	B	100
Nevada	5	838	2	1998	L. Neel, Nevada Division of Wildlife; D. Withers, Stillwater NWR	B	40
New Mexico-Lower Rio Grande	3	600	3	1996	S. Williams, New Mexico Game and Fish	A	100
Oregon							
Columbia River Estuary	5	6,300	1	2000	D. Roby, Oregon State University	A or B	100
Coast	27	2,939	22	1988-1992	Carter *et al.* 1995	A	100
Interior	8	913	5	1999	M. Naughton, USFWS	B	63
Washington	43						
Coast	39	278	10	1999	M. Naughton, USFWS	A	100
Grays Harbor	2	440	2	1992	Carter *et al.* 1995	A	100
Columbia River mouth	1	125	1	1995	M. Naughton, USFWS	A	100

Table 2. (Continued) Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

Regions of documented breeding	No. known colonies since @1970	No. pairs last census	No. colonies last census	Year of last census	Source (data are unpublished, obtained through personal communications unless otherwise noted)	Estimate quality	% known active colonies visited
Interior	1	652	1	1997	J. Stofel and J. Tabor, Washington Dept of Fish and Wildlife	B	100
Subtotals	248	33,000	169				
Zone 3 Interior							
Alberta	NA	7,000	NA	1992	S. Brechtel, AB Provincial Non-game Dept. (in Hatch 1995)	D	NA
Colorado	28	1,000	NA	1990s	Kingery 1998; R. Levad, CO Bird Observatory	B	NA
Iowa	10	>844	5	1998	K. Bogenschutz, Iowa Dept Natural Resources; Ehresman 1996	B	NA
Idaho	11	>1,175-1,401	11	1993	Trost 1994	A	100
Illinois	14	>754	6	1997	J. Herkert, Il Endangered Species Protection Board	A or B	100?
Indiana	0	0					
Kansas	6	small (all colonies < 300 pairs)	NA	1992-1997	W. Busby, Kansas Biological Survey	E	NA
Kentucky	0	0			B. Palmer-Ball, Kentucky State Nature Preserve's Commission		
Manitoba (province-wide)	156	NA					NA
Lake Winnipegosis	33	36,180	33	1999	B. Koonz, Manitoba Dept. Natural Resources	A	100
Michigan	48	31,079	45	1997	Cuthbert *et al.* 2003	A	100
Minnesota	75	8-10,000	NA	late 1990s	McKearnan 1997; Henderson 2001	D	NA
Missouri	0	0		late 1990s	J. Wilson, Missouri Dept. Conservation		
Montana	50-100	~ 40/colony	NA	late 1990s	D. Flath, Montana Fish, Wildlife and Parks	E	NA
North Dakota	>12	?	NA	late 1990s	C. Grondahl, North Dakota Game and Fish Dept.		NA
Nebraska	14	>840	1	2000	J. Dinan, Nebraska Game and Parks Commission	B	NA
New Mexico (Upper Rio Grande)	3	130	3	1996	S. Williams, New Mexico Game and Fish	A	100
New York (inland)	12	9,072	12	1997	R. Miller, New York State Dept. of Environmental Conservation	A	100
Ohio	2	1,510	2	1998	M. Shieldcastle, Ohio Division of Wildlife	A	100
Ontario	116	35,159	74	1997	D. V. Weseloh, Canadian Wildlife Service	A	100
Quebec (southwestern)	5	212	5	1990-1997	J. F. Rail, Canadian Wildlife Service	D	100

Table 2. (Continued) Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

Regions of documented breeding	No. known colonies since @1970	No. pairs last census	No. colonies last census	Year of last census	Source (data are unpublished, obtained through personal communications unless otherwise noted)	Estimate quality	% known active colonies visited
South Dakota	36	>2,962	11	1991	R. Peterson, South Dakota Ornithologists' Union; Peterson 1995	B	31
Saskatchewan	19	19,547	10	1991	K. Roney, Royal Saskatchewan Museum	A	100
Tennessee	3	29	1	1999	R. M. Hatcher, Tennessee Wildlife Resources Agency	A	100
Texas (northern)	NA	NA			J. Herron, Texas Parks and Wildlife		
Utah	8	>362	4	1996	F. Howe, Utah Division of Wildlife Resources	B	NA
Vermont	5	2,805	5	1999	L. Garland, Vermont Fish and Wildlife	A	100
Wisconsin	46	10,546	23	1997	S. Matteson, Wisconsin Dept. of Natural Resources	A	100
Wyoming	25	364	8	1994	A. Cerovski, Wyoming Game and Fish Dept.	B	NA
Subtotals	704-754	>169,570	>259				
Zone 4 Southeastern U.S./Caribbean							
Arkansas (southwestern)	1	100	1	1999	M. Hoy, USDA/WS; K. Howe, Arkansas Game and Fish Commission	A	100
Bahamas	?	500	?	1975	A. Sprunt, National Audubon Society (in Hatch 1995)	E	
Cuba	?	500	?	?	Palmer 1962 (in Hatch, 1995)	E	
Florida	110	6,745	84	1999	J. Rodgers, Jr., Florida Game and Fresh Water Fish Commission	A	100
Georgia	7	40	7	1993-1996	B. Winn, Georgia Dept. of Natural Resources	D	100
Louisiana	2	447	2	1994-1995	B. Vermillion, Louisiana Dept. of Wildlife and Fisheries	D	100
Mississippi	2	33	2	1998	Reinhold *et al.* 1998	A	100
North Carolina	3	135	1	1996	D. H. Allen, North Carolina Wildlife Resources Commission	A	100
Oklahoma	2	30	1	1996	M. Howery, Oklahoma Dept. of Wildlife Conservation	A	100
Puerto Rico/Virgin Is	0	0		NA			
South Carolina	17	895	10	1996	T. M. Murphy, South Carolina Dept. of Natural Resources	A	100
Texas (south)	NA	NA	NA	NA		None	

Table 2. (Continued) Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

Regions of documented breeding	No. known colonies since @1970	No. pairs last census	No. colonies last census	Year of last census	Source (data are unpublished, obtained through personal communications unless otherwise noted)	Estimate quality	% known active colonies visited
Yucatan	?	45	?	1985	A. Sprunt, National Audubon Society (in Hatch 1995)	E	
Subtotal	144	9,470	>108				
Zone 5 Northeast Atlantic Coast							
Connecticut	26	961	17	1998	J. Victoria, Dept. of Environmental Protection	A	100
Delaware	1	3	1	1991	C. M. Heckscher, Division of Fish and Wildlife	A	100
Maine	135	17,100	117	1994-1995	R. B. Allen, Dept. of Inland Fisheries and Wildlife	A	100
Maryland	4	1,046	4	1999	D. F. Brinker, Maryland Dept. of Natural Resources	A	100
Massachusetts	28	7,833	27	1995	B. G. Blodget, Massachusetts Division of Fisheries and Wildlife	A	100
New Brunswick	25?	9,278	15	1986-1991	Lock *et al.* 1994, Erskine 1992	B, D	NA
Newfoundland	8-9	343-363	6-7	1996	Korfanty *et al.* 1997	A	100
New Hampshire	3	20	1	1998	J. Kanter, New Hampshire Fish and Game	A	100
New Jersey	5	small (<100 pairs/colony)	5	1993-1997	J. Walsh, Cape May Bird Obs.; R. Kane, NJ Audubon Society	D	100
New York-Atlantic Coast	12	3,274	9	1998	R. Miller, New York Dept. Environmental Conservation	A	100
Nova Scotia	102	12,000	90	1992	Milton *et al.* 1995	A	100
Pennsylvania	1	3	1	1998	D. Brauning, PA Game Commission; R. Ross, USGS/BRD	A	100
Prince Edward Island	12	7,695	8	1999	R. Dibblee, Dept. of Technology and Environment	A	100
Quebec	122	25-27,000	70	1990	Chapdelaine and Bedard 1995; J.F. Rail, Canadian Wildlife Service	D	100
Rhode Island	10	2,058	9	1997	C. Raithel, Division of Fish, Wildlife and Estuarine Resources	A	100
Virginia	2	60-70	1	1997	D. Schwab, Virginia Dept. of Game and Inland Fisheries	A	100
Subtotal	496-497	>86,674	381-382				

of cormorants for food referred either to Massachusetts or Rhode Island or both. Mackay (1894) noted that in the late 1800s, hundreds were observed every spring around Newport County, Rhode Island, at a rock outcrop near Sachuest Point called Cormorant Rocks, which was named on a map as early as 1776. Cormorants were also present historically in Virginia but seasonal presence and distribution is not clear (Lewis 1929).

As in the other breeding zones, sometime during European settlement DCCOs began declining in most parts of the Atlantic range due to heavy human persecution (Lewis 1929; Mendall 1936; Gross 1944; Krohn *et al.* 1995). By the early 19th century, they were extirpated in New England. By the late 19th and early 20th centuries, breeding cormorants had disappeared from Nova Scotia and were greatly reduced in the other Maritime Provinces and Quebec (Lewis 1929; Erskine 1992). Although we found no early estimates or archaeological evidence to which historic and current abundance can quantitatively be compared, early comments and records suggest cormorants were very abundant in this breeding zone prior to European settlement (Williams 1643; Audubon 1843; Reeks 1869; Champlain 1922; Goss 1889; Townsend 1917). Mendall (1936) cites Morton (1637), who wrote of cormorants in New England, "There are greate store of Pilchers: at Michelmas, in many places, I have seene the Cormorants in length 3.0 Miles feedinge upon the Sent." Lewis (1929) reported that several 17th century references mention the abundance of cormorants in Virginia, and that in 1610, one anonymous author reported cormorants among the birds in Virginia rivers "in such abundance as are not in all the world to be equaled."

DISCUSSION

The current breeding range of the DCCO is similar to pre-1900, although some changes have occurred. The range has retracted in Alaska and in southeastern U.S, but expanded along the Atlantic Coast and in the Interior. In the latter regions, some important changes may represent re-colonization events. DCCO historic abundance and widespread distribution has several implications for current conservation and management efforts, discussed below.

The Great Lakes Population

The Great Lakes region is one of the most important areas in the human-cormorant conflict, and concerns from this region have strongly influenced federal policy decisions for cormorants. Most of the conflict centers on perceived impacts to fisheries from cormorant predation. Currently many factors affect the health of the Great Lakes ecosystem; one of the most significant is establishment of >160 exotic invasive species (Mills *et al.* 1993; Ricciardi 2001). Of these, several (e.g., zebra mussel (*Dreissena polymorpha*) alewife (*Alosa pseudoharengus*), sea lamprey (*Petromyzon marinus*) directly and indirectly impact valuable fisheries (e.g., Mills et al. 1993; Belyea *et al.* 1999). Additionally, many other variables (e.g., water temperature variation, declines in benthos abundance) also impact fisheries (Hoyle *et al.* 1998, Pothoven *et al.* 2001). Nevertheless, in areas where declines in sport fish species and catch have occurred, many anglers and fisheries biologists attribute declines to recent increases in DCCO numbers (e.g., Fielder 2004). Additionally, some anglers believe cormorants are non-native to the region, and report that the species was intentionally introduced by the Japanese (F. Cuthbert, pers. obs.). The media has also published articles stating the species is an exotic (Sharp 2004). Finally, large cormorant colonies in this region have once again become the focus of vandalism and destruction as well as legal control activities. For example, in the late 1990s-2000, about 1,350 DCCO adults and chicks were illegally shot at Little Galloo Island, Lake Ontario, New York, and at Little Charity Island, Saginaw Bay, Michigan, by anglers who believed cormorants were responsible for poor catches (Kloor 1999; Lounsbury 2000). In summer 2004, all colonies in the Les Cheneaux Islands area, Michigan, were targeted by USDA/WS for control (e.g., harassment, oiling eggs, shooting adults) to aid the ailing yellow perch fishery (USDA/APHIS/WS 2004), despite an earlier rigorous study of cormorant predation in this area that concluded cormorants were not a substantial factor in yellow perch mortality (Belyea 1999).

One critical component that shapes perception of a species' role within an ecosystem is knowledge of species history. Previously, occurrence and movement of cormorants through the Great Lakes in the early 1900s was described as an "invasion" (Postupalsky 1978; Weseloh and Collier 1995). Perception of this species as an invader will strongly influence its management because invasive species, variously described as "exotics", "nonindigenous" or "aliens," typically spread and cause net harm to a system (Lodge and Shrader-Frechette 2003). Review of all available records to assess the history of the Double-crested Cormorant in the Great Lakes suggests characterization as an "exotic" or "invasive" is inappropriate, and history in the Great Lakes needs further exploration. Considering records documenting nesting prior to 1900 are available from the western and southern border states of the Great Lakes, and abundant nesting habitat would have been available, apparent species absence is puzzling.

Historic Populations and Current "Overabundance"

Most historic records cited in this work were obtained during the period of European settlement, particularly in the 19th century (Table 1). We assume abundances that existed during this period represent populations under relatively natural conditions (i.e., abundance attained when relatively free from artificial/human modified elements that could lead to inflated or diminished numbers). However, it is possible that in some locations settlers were encountering spectacularly abundant concentrations of cormorants and other wildlife that were responding to release from Native American harvest. Broughton (2004) suggests that the abundant wildlife populations observed in pre-1900 California resulted after Native Americans experienced dramatic disease-based population declines through coastal contact with European explorers in the 16th century. Thus, for some species, assuming that the pre-1900 time period represents the baseline or benchmark of past populations, may be a questionable assumption (Broughton 2004). Nevertheless, although the impact of Native American harvest on cormorants at a large scale (e.g., state, regional, continental) is not known, the breadth of cormorant records spanning hundreds of years and locations across the continent (Table 1) suggests the Double-crested Cormorant had been an abundant species for a substantial time. Additionally, the clearly documented record of human persecution throughout the European settlement period marks a significant era in the known history of the cormorant, to which massive population declines and local extirpations can be traced.

On a continental level, comparisons of historic and current records indicate cormorants were likely more abundant during initial European settlement than they are today. Therefore, describing the current continental population at an "all time" or "historic" high is misleading. Additionally, in several areas across the continent, portions of the public and some natural resource biologists view the DCCO as a recent addition to the regional avifauna despite historic records that demonstrate new nest records actually represent re-colonization of former breeding areas (Wires *et al.* 2001). Lack of knowledge about historical distribution and abundance has led to significant misconceptions about numbers of cormorants the environment may support. For example, some portions of the public in conflict with this species (e.g., anglers, aquaculturalists) consider mid-century (pre-1980) numbers to be the "norm" for DCCOs; however, numbers and distribution during this period were greatly diminished due to contaminants and persecution (e.g., Gress *et al.* 1973; Vermeer and Rankin 1984; Weseloh *et al.* 1995). Similarly, in the Great Lakes, where cormorants are currently at recorded highs, growth during much of the 20th century was suppressed through legal and illegal control activities and contaminants (Ludwig and Summer 1995; Weseloh *et al.* 1995). Thus population size prior to the 1970s (when national legislation protecting cormorants and reducing contaminants was introduced) was smaller due to human intervention and environmental degradation, rather than to natural regulation and biological carrying capacity. Misconceptions about historic numbers and what is "normal" in current ecosystems, rather than science, has fueled much of the debate about need to control DCCOs in North America.

The term "overabundant" is a judgment that needs qualification. Kushlan *et al.* (2002) imply one way to judge overabundance is to determine if a species has exceeded historical norms. This criterion is useful because comparison of current to historic numbers may help determine biologically if there are "too many" individuals of a species. Based on available records, the continental DCCO population has not exceeded historical norms. Additionally, no study has demonstrated DCCOs exceed biological carrying capacity by surpassing food supplies or habitat. Although concern about potential impacts to various resources has been reported in several areas (USDI/FWS 2003b), negative changes in natural resources directly linked to DCCO population growth via rigorous scientific study have been documented at only a few locations (Wires *et al.* 2001; Cuthbert *et al.* 2002).

In biological terms, we suggest characterization of the continental DCCO population as overabundant is inappropriate. This characterization is applicable, at best, only on a local and site-specific level where numbers can be demonstrated to outstrip resources. Applied to the eastern U.S. population, use of the term "overabundant" is meaningful only in terms of "wildlife acceptance capacity" (Decker and Purdy 1988). This term was created to highlight that many wildlife or social acceptance capacity levels may exist for a particular wildlife population at any point in time; this is unlike the concept of biological carrying capacity. Usually, wildlife acceptance capacity is far smaller and more variable than that determined by biological carrying capacity.

Conservation vs. Management Goals

Over the last decade and a half, large-scale conservation plans for birds in the Americas have developed that depart from the traditional narrow focus on threatened and endangered species, and now encompass broader and more representative goals, such as that defined by the vision of Partner's in Flight's (PIF) "keep common birds common" (Fitzpatrick 2002). Waterbird conservation plans at national and continental scales directly link species and population goals to historic distribution and abundance (Milko *et al.* 2003; Kushlan *et al.* 2002). Fitzpatrick (2002) takes current bird conservation initiatives one step further and offers the following as a robust mission statement: "Ensure persistence of all American bird populations in their natural numbers, natural habitats, and natural geographic ranges . . ." In these more recent initiatives and perspectives, historic distribution and abundance provide the basis for conservation focus. Thus, when designing management and conservation plans, and developing biologically meaningful population objectives, it is important to recognize where and in what numbers and habitats DCCOs formerly and naturally occurred. Because very large numbers have been typical for this species historically, population targets based on fishery objectives or other human imposed values may be readily surpassed and likely will require intensive management.

In some areas, return of DCCOs after a long period of absence or local/regional rarity has created conflicts over resources because humans are not accustomed to dense concentrations of DCCOs and now more intensively use areas that were formerly occupied by cormorants (Wires *et al.* 2001; Wires and Cuthbert 2003). These conflicts have led to policy decisions and management plans (Glahn *et al.* 2000; USDI/FWS 2003c; USDA/APHIS-WS 2004) that are incompatible with current conservation goals (Wires and Cuthbert 2001; Fitzpatrick 2002; Kushlan *et al.* 2002; Milko *et al.* 2003). For example, the management plan prepared for DCCOs to minimize damage to southern aquaculture (Glahn *et al.* 2000) proposes that southern breeding colonies be managed at levels compatible with aquaculture to forestall future depredation problems. Cormorants have recolonized portions of Arkansas and Mississippi after several decades of absence from these states; current colonies are small and few in number (Table 2). Despite no record of cormorant breeding in Arkansas since 1951, most (85%) of the birds at the only known nesting site were collected for research by USDA/APHIS-WS when they resumed breeding in 1999 (Hutchinson 1999). The Arkansas Wildlife Services state director commented that he hoped "we can keep this population down and maybe eliminate it . . . if we let it get out of control we could have cormorants throughout the year" (The Catfish Journal 1999; Hutchinson 1999). Though year-round residence in Arkansas by DCCOs may result in more conflicts with the aquaculture industry, year-round residence was documented historically (Howell 1911; James and Neal 1986).

In spring 2004, several islands in the Great Lakes were selected for large-scale cormorant control but these islands have also been identified as providing significant habitat for birds. For example, the islands in northern Lake Huron, MI, which include the Les Cheneaux Islands, have been proposed as an Important Bird Area (J. P. Cecil, Audubon, pers. comm.), and several of these islands with nesting cormorants were previously prioritized for conservation because of their regional importance to breeding colonial waterbirds (Wires and Cuthbert 2001). At Presqu'ile Provincial Park in Ontario, a formally designated Important Bird Area, over 6,000 breeding cormorants were killed in 2004, allegedly to protect an old-growth forest (Ontario Parks 2005).

Conservation of DCCOs and other abundant waterbird species cannot be effective without a unified conservation philosophy based on knowledge of historical populations and policy decisions founded on sound science. Public dissatisfaction with waterbirds is one of the greatest threats affecting long-term survival of waterbird populations (Kushlan *et al.* 2002). Much of this negative attitude is held because waterbirds eat fish and are perceived as competitors. In the case of the DCCO, its image is especially negative; the human-cormorant conflict is exacerbated because the species was not present or existed in very low numbers for all or most of current human memory in North America.

The fact that very large numbers of DCCOs existed prior to European settlement has fundamental implications for multiple natural resource management issues. Historically, vigorous fish populations sustained large numbers of fish-eating birds; in relatively natural systems, this is still possible (e.g., Davoren and Montevecchi 2003). In highly modified systems (e.g., Great Lakes), controlling native predators does not address the diverse problems that affect this ecosystem and its ailing fisheries. However, in many areas of the Great Lakes, DCCOs have been identified as the major factor limiting fish populations. This, in turn, has led to the development of population objectives for cormorants based largely on fishery objectives. For example, agencies managing cormorants in the U.S. eastern basin of Lake Ontario and on Long Island (Oneida Lake) (New York Department EC), and Canadian colonies on lakes Huron and Ontario (Ontario Ministry of Natural Resources) have established cormorant population sizes hypothesized to increase local fisheries or to achieve local fishery yields (Farquhar *et al.* 2001, 2004; Council of Lake Committees 2003; NYSDEC Newsletter 2004).

Although managing cormorants may benefit some fisheries and resolve human-cormorant conflicts, setting population objectives for cormorants based entirely on fishery or other objectives derived from human values significantly departs from the concept of conserving birds in natural numbers and natural habitats (Fitzpatrick 2002). Given the global state of ailing fisheries and increasing government sensitivity to wildlife acceptance capacity, self-regulating populations of cormorants may only be possible in cormorant "safe zones" where human interests are not allowed to influence cormorant numbers. Because few such "safe zones" are likely to exist, those committed to the conservation of fish-eating birds should vigorously oppose strategies that set population objectives based entirely on human interests rather than species biology and regional ecology. Finally, we urge the avian conservation community to support broad conservation strategies based on ecosystem health and process that recognize humans, fish and cormorants as three components of a complex system driven by many species and dynamic interactions.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ECOSYSTEMS, TRIBAL AND
PUBLIC AFFAIRS

August 19, 2014

Ms. Sondra Ruckwardt
U.S. Army Corps of Engineer District, Portland
Attn: CENWP-PM-E/Double-crested Cormorant Draft EIS
P.O. Box 2946
Portland, Oregon 97208-2946

Re: Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary Draft Environmental Impact Statement
EPA Region 10 Project Number: 14-0032-COE

Dear Ms. Ruckwardt:

The U.S. Environmental Protection Agency has reviewed the Draft EIS for the Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. We are submitting comments in accordance with our responsibilities under the National Environmental Policy Act and Section 309 of the Clean Air Act. Thank you for the opportunity to offer comment on the proposed action.

In response to Reasonable and Prudent Alternative Action 46 (RPA 46) of the 2014 Supplemental Federal Columbia River Power System Biological Opinion prepared by NOAA Fisheries, the Corps proposes to reduce the double-crested cormorant (DCCO) population on East Sand Island in the Columbia River estuary from approximately 14,000 breeding pairs to approximately 5,600 breeding pairs[1]. In addition to the No Action Alternative A, the DEIS presents 3 action alternatives that would reduce the DCCO population using a combination of non-lethal and lethal methods. Alternative B would emphasize non-lethal hazing, habitat modification, and limited (lethal) egg take. Alternative C (the Corps Preferred Alternative) would emphasize lethal take (shooting) of approximately 16,000 DCCOs and limited egg take followed by terrain modification and hazing to allow nesting of DCCOs (at or below target population levels) within a reduced designated area. Alternative D would apply lethal take (shooting) of approximately 16,000 DCCOs, followed by terrain modification, hazing, and egg take to remove all DCCOs from East Sand Island and disperse the remaining approximate 5,600 breeding pairs away from the Columbia River Estuary.

[1] A colony size of ~ 5,600 breeding pairs could remain, but no management actions would be taken to ensure a minimum colony size (Exec. Sum. p. 10).

Based on the information provided in the DEIS, we are rating the DEIS as EC-2, Environmental Concerns, Insufficient Information. An explanation of the EPA rating system and detailed comments are enclosed. The reasons for this rating are as follows:

- We believe that additional analysis is needed to more fully evaluate non-lethal population control alternatives.
- The proposed action does not adhere to the Guiding Principles established by the Pacific Flyway Council regarding Avian Predation on Fish Resources[2].
- The proposed lethal take of approximately 16,000 double-crested cormorants would also likely lethally take many non-target bird species, all of which are native and integral to the natural ecosystem and processes of the Columbia River Estuary.
- The Preferred Alternative would reduce the East Sand Island DCCO colony by 56%. This would eliminate 25 to 26% of the western population of DCCOs (Ch. 4, p. 12-13), which, except for the East Sand Island population is in substantial decline (Ch. 3, p.3).
- Additional information is needed to support the conclusion that 1990 western population levels of DCCOs, reduced as a result of implementing the Preferred Alternative, would be viable and sustainable.
- A DCCO western population viability analysis is needed. Among other viability and mortality factors, the analysis would need to identify current and likely future habitat availability for DCCOs within the range of the western population that factors in current and projected future climate change conditions.
- The analysis of economic benefits from reducing DCCO predation on juvenile salmonids per RPA 46 may overstate the benefits and understate the costs. Also, the analysis does not incorporate compensatory mortality and recent science on this subject.
- To put this proposed action in context, the EIS should include discussion of other means available to the Corps to assist recovery of ESA-listed salmonids.

We acknowledge and respect NOAA Fisheries' expertise, authority and effort to restore salmonid populations, and likewise acknowledge USFWS' expertise and authority for managing DCCO and other migratory bird populations. We encourage the collective responsible agencies to continue to pursue and use all appropriate, applicable science to select actions that will best maintain viable populations of these species.

[2] Pacific Flyway Council. 2012. Pacific Flyway Plan: A Framework for the Management of Double-crested Cormorant Depredation on Fish Resources in the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 55pg.

Thank you for the opportunity to offer comment on the proposed Cormorant Management Plan. We look forward to continued involvement in the NEPA process for this project. If you have questions or would like to discuss our comments, please contact me at (206) 553-1601 or via electronic mail at reichgott.christine@epa.gov, or Elaine Somers at (206) 553-2966 or via electronic mail at somers.elaine@epa.gov.

Sincerely,

Christine B. Reichgott

Christine B. Reichgott, Manager
Environmental Review and Sediment Management Unit

Enclosures

1. Detailed Comments on the DCCO Management Plan
   to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary Draft EIS
2. EPA Rating System

U.S. Environmental Protection Agency
Detailed Comments on the DCCO Management Plan
to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary Draft EIS

Guiding Principles of the Pacific Flyway Council regarding Avian Predation on Fish Resources
The PFC guidance[3], which includes six main principles and their subparts, states that, "Inherent in this policy is the recognition that management of avian predation must be implemented in a manner and at a scale consistent with the conservation of migratory bird populations and the fish populations with which they interact." The guiding principles direct that non-lethal control actions that result in no direct take of nongame migratory fish-eating birds should be attempted first. Information in the DEIS does not support PFC guidance principles such as:

- Principle 4: Responses to perceived avian predation issues are based on sound science – (c) Expectations of how management actions will reduce impacts to affected fish populations are explicitly addressed; (d) Expected outcomes of management actions on affected avian populations are clearly understood.
- Principle 5: Important considerations when evaluating the need for management action in response to avian predation of fish resources – (a) Assessment of population-level impacts for both migratory birds and fish; (e) Cost-benefit analyses for proposed management strategies.
- Principle 6: Methods for reducing avian predation on fish resources are always implemented within existing regulatory frameworks – (b) Non-lethal control actions that result in no direct take of nongame migratory fish-eating birds should be attempted first.

NOAA Fisheries used the 1990s level DCCO population as a base for calculating their 2014 gap analysis, which is a point in time used to show change in potential DCCO fish consumption; it does not represent a scientific assessment of what would be considered a viable population size for DCCOs. The DEIS also states that NOAA's calculation of fish eaten by DCCOs is based upon PIT tags and a bioenergetics model. However, no information about the bioenergetics model is provided in the DEIS or its appendices.

NOAA's Biological Opinion for the FCRPS prescribes a 56% reduction in the ESI DCCO colony, resulting in a reduction of 25 to 26% of the western population of DCCOs, which are currently an order of magnitude lower than historical populations. DCCOs are still rebounding from severe decline resulting from impacts such as unregulated hunting, harassment, and DDT-induced reproductive failure.

The DEIS acknowledges uncertainties associated with the Preferred Alternative and that the proposed action could be taken without a clear understanding of the consequences. For example, the DEIS states (Ch. 4, p. 15) that while there are examples elsewhere of DCCO and great cormorant populations increasing after lethal management, those populations are an order of magnitude larger than the western population of DCCOs, and there is more uncertainty in how the western population of DCCOs could respond to the proposed levels of culling. There have not been large-scale culling programs within the western population of DCCOs, the western population exhibits little to no growth except for East Sand Island. ESI is not within a connected matrix of other large breeding colonies within the affected

[3] Pacific Flyway Council. 2012. Pacific Flyway Plan: A Framework for the Management of Double-crested Cormorant Depredation on Fish Resources in the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 55pg.

environment, and additional annual authorized take is occurring elsewhere within the western population (Ch. 4, p. 16).

Recommendation: Conduct further studies and gather scientific information that support decisions regarding DCCO predation reduction and maintenance of a viable western population of DCCOs.

Cost-benefit analysis and Compensatory Mortality

The DEIS (Ch. 4, p. 38-40) projects the maximum potential regional economic benefits that can be derived from implementing the DCCO predation reduction program would be $1.5 million, a 3.1% increase in revenue. The significance of this increase on a per capita basis when spread among the many commercial fishermen, recreational fishing-related businesses, and tribes has not been quantified and thus is not clear. In addition, this maximum possible increased revenue may be overestimated because neither compensatory mortality[4] nor the costs of implementing the DCCO predation reduction program nor potential increased costs outside the Columbia River Estuary that may be incurred from DCCO dispersal have been factored into this estimate. Should the DCCO predation reduction efforts and related direct and indirect impacts result in ESA listings of the western DCCO population and/or non-target species populations, the costs for ESA-related expenditures to local, state, federal governments, tribes, and other entities would need to be added to the costs of the proposed DCCO predation reduction program.

Based on these factors and other information[5], the costs could potentially outweigh economic benefits of implementing the proposed program. Other unanticipated ecosystem effects may trigger additional direct and/or indirect costs, loss of ecosystem integrity and services[6].

Recommendation: In the Final EIS, factor the additional costs of elements such as those discussed above, including compensatory mortality, into the analysis of economic effects. Acknowledge the potential for additional costs that cannot be quantified or fully predicted due to the complexity and uncertainty of ecological effects from the proposed action.

Ecosystem Health and Process Considerations

We have concerns regarding an apparently increasing tendency to set population objectives for cormorants and other fish-eating birds, fish, and other wildlife (such as, Caspian terns, pinnepeds, and pike minnows) based disproportionally on fishery or other human interests. We agree with Wires and Cuthbert[7] that population objectives should be based on species biology, regional ecology, ecosystem health and process "that recognize humans, fish and cormorants as three components of a complex system driven by many species and dynamic interactions."

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[4] Compensatory mortality occurs when reduced juvenile salmonid mortality from DCCOs is replaced by another source of mortality (Ch.4, p.93)

[5] For example, the cessation of research, monitoring, dissuasion, and other disturbance to the DCCO colony would reduce number of DCCOs at the Astoria Bridge, which increased during dissuasion experiments (Ch. 4, p. 43), thereby reducing need for maintenance and USDA-Wildlife Services at transportation and other facilities.

[6] Consider, for example, "Reef-eating threatened fish force scientists to take whole-system approach to conservation", http://www.eenews.net/greenwire/2014/07/30/stories/1060003773

[7] Wires, Linda R., Cuthbert, Francesca J. *Historic Populations of the Double-Crested Cormorant (Phalacrocorax auritus): Implications for Conservation and Management in the 21st Century.* Waterbirds: The International Journal of Waterbird Biology. Vol. 29, No. 1 (March, 2006), pp. 9-37

Birds are considered to be good indicators of the health of the ecosystem[8]. Based on information presented in the DEIS (Chapters 3 and 4), the DCCO western population is either static or in decline throughout its range except for East Sand Island. Recent growth in the western DCCO population is attributed almost entirely to the ESI population. The ESI population is growing as a result of immigration from other locations, as well as through reproductive success. This is largely due to the stable food supply afforded by forage fish and hatchery releases of juvenile salmon below Bonneville Dam. Studies reveal that juvenile salmonids comprise an average of only 10 to 15% of the DCCO diet on East Sand Island. The majority of DCCO diet consists of forage fish. Diet tends to shift to juvenile salmonids when high river flows and hatchery fish releases occur in spring. The lower fitness of hatchery fish makes them susceptible to predation.

In the Salish Sea and throughout the west, fish eating waterbirds are experiencing severe declines. East Sand Island is one of few locations where DCCOs and a wide variety of other waterbirds, shorebirds, and waterfowl are thriving, such that the Island has been designated a Globally Important Bird Area (IBA) by both the Audubon Society and the American Bird Conservancy. Because DCCOs are highly philopatric, DCCO immigration to ESI may indicate that conditions for survival are likely unsuitable elsewhere. This should be factored into any DCCO management plans, as well as the fact that even with the increasing DCCO population on ESI, the population of ESA-listed salmonids has been increasing.

Recommendation: Since RPA 46 is discretional,[9] fully investigate non-lethal alternatives and the other means available to the Corps to support recovery of listed fish populations.

Impacts to non-target species

We are concerned that the proposed action would result in the take of non-target species due to misidentification, night shooting, direct and indirect effects of disturbance, and incidental crushing of eggs, chicks, and fledglings. Eighty-four species of birds have been identified on the 60-acre East Sand Island. It supports the largest breeding population of Caspian terns and cormorants in the world, and the largest post-breeding roost site for Brown pelicans on the West Coast. The Streaked horned lark, recently listed as threatened under the ESA, also uses the island. Both Audubon Society and the American Bird Conservancy have designated East Sand Island as a Globally Important Bird Area. Brandt's and pelagic cormorants are the non-target bird species of most concern with respect to lethal take because they are easily misidentified and Brandt's cormorants nest among DCCOs (Ch. 4, p. 48). Streaked horned larks are of most concern off East Sand Island where hazing in the Columbia River Estuary may become more intensified.

Recommendation: Because East Sand Island is identified as high value bird habitat, we recommend selection of an alternative that fully minimizes impacts to migratory and resident species.

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[8] Declines in marine birds trouble scientists: Encyclopedia of Puget Sound. http://www.eopugetsound.org/articles/declines-marine-birds-trouble-scientists?utm_source

[9] http://www.fws.gov/endangered/what-we-do/faq.html

U.S. Environmental Protection Agency Rating System for Draft Environmental Impact Statements Definitions and Follow-Up Action*

Environmental Impact of the Action

LO – Lack of Objections

The U.S. Environmental Protection Agency (EPA) review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC – Environmental Concerns

EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce these impacts.

EO – Environmental Objections

EPA review has identified significant environmental impacts that should be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no-action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU – Environmentally Unsatisfactory

EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the Council on Environmental Quality (CEQ).

Adequacy of the Impact Statement

Category 1 – Adequate

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis of data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2 – Insufficient Information

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses or discussion should be included in the final EIS.

Category 3 – Inadequate

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the National Environmental Policy Act and or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

* From EPA Manual 1640 Policy and Procedures for the Review of Federal Actions Impacting the Environment. February, 1987.